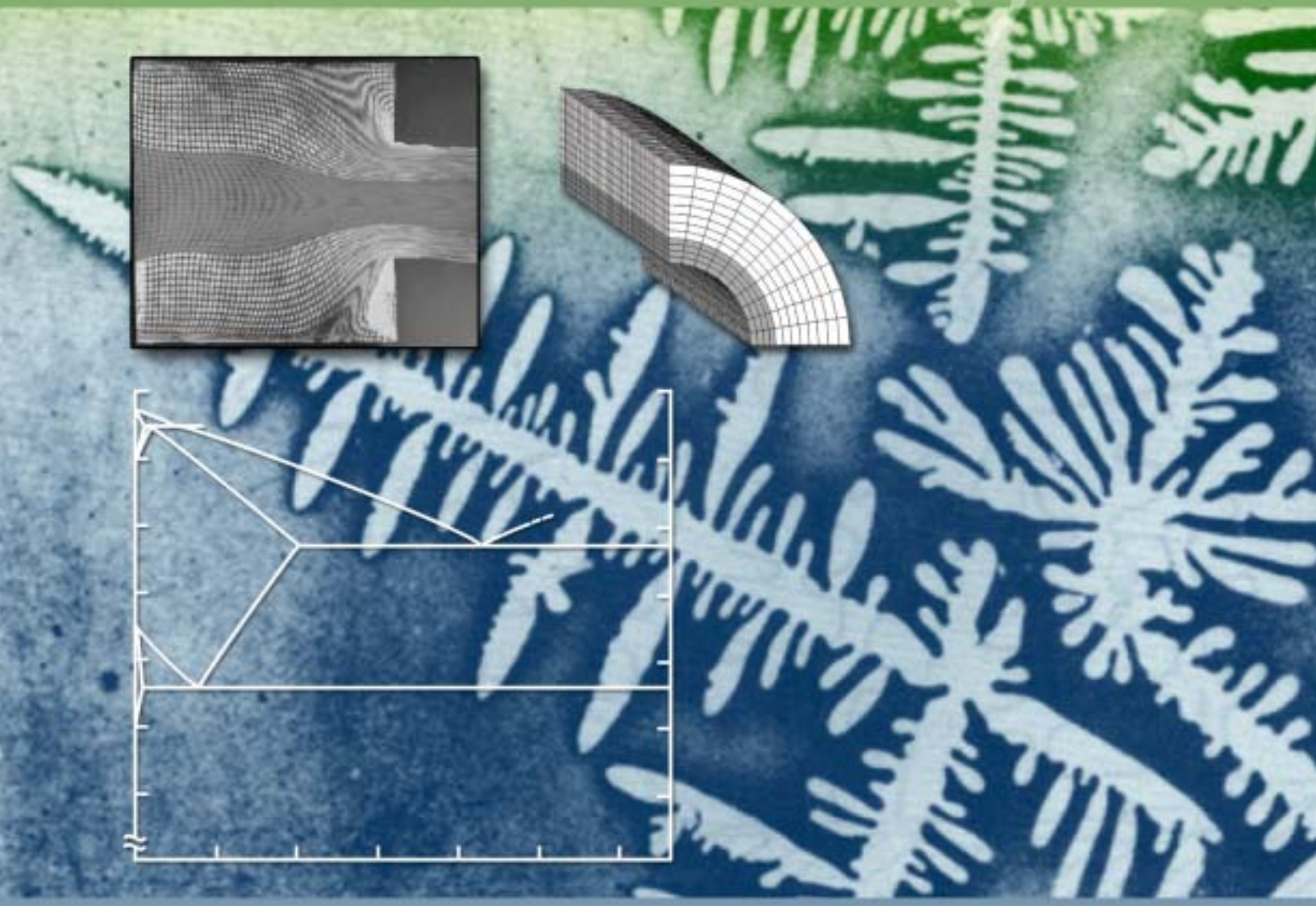
Materials



Industrial Materials for the Future Annual Report

Fiscal Year 2003

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry
through improvements in energy and environmental performance

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Industrial Technologies Program - Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. Through an innovative strategy known as Industries of the Future (IOF), EERE's Industrial Technologies Program (ITP) seeks to improve the energy intensity of the U.S. industrial sector through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private-sector investment.

The IOF strategy maximizes the energy and environmental benefits of ITP's process-specific technology investments by forming collaborative partnerships with energy–intensive industries. These collaborations aim to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. The IOF public-private partnerships also facilitate voluntary efforts, such as the President's Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions. ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 75 percent of industrial energy consumption:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum Refining
- Steel

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the IOF partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

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The availability of appropriate materials and processing methods is often critical to the successful realization of a new engineering or process concept. The success or failure of many industrial energy efficiency concepts, in particular, depends on the selection of suitable materials and fabrication techniques because of the severe demands on materials performance imposed by harsh industrial environments. As evidence, materials R&D is identified as a high priority in every IOF roadmap. The removal of materials barriers to energy efficiency in the manufacturing sector is the focus of the Industrial Materials for the Future (IMF) portfolio.

R&D Highlights

FY 2003 *R&D 100 Awards* - A new coating for sliding and rotating materials sponsored by DOE was selected by *R&D Magazine* as a 2003 *R&D 100 Award* winner. These awards honor the top 100 technologically significant products that have become commercially available within the past year. The Nanostructured Carbide-Derived Carbon (CDC) coating technology, developed with R&D funding from the IMF, is the result of research conducted by Drexel University, the University of Illinois at Chicago, Argonne National Laboratory, and industrial partners. The coating has exceptional friction and wear properties in wet, dry, and high-temperature environments, and is considered well-suited as an application for dynamic seals for rotating equipment (e.g., pumps).

A second IMF project was also selected by *R&D Magazine* as a winner of a 2003 *R&D 100 Award*. The Ultrananocrystalline Diamond Coatings project has developed coatings to improve wear resistance on mechanical pump seals. The coatings were the result of research by Argonne National Laboratory and industrial partners. The award specifically honored the development of a large-scale, six-inch reactor used to deposit a diamond coating on materials for various applications, including pump seals.

Partnership Highlights

FY 2003 Solicitation - The IMF R&D portfolio funded 27 existing and new projects, totaling $12.7 million in fiscal year 2003. Over 110 project partners from industry, universities, industrial associations, and national laboratories were involved in IMF R&D efforts. The IMF FY 2003 solicitation received 59 proposals, demonstrating the wide industry interest in materials R&D. The IMF selected 12 new projects for negotiation and will provide more than $20 million over the course of these projects to improve energy efficiency in the U.S. manufacturing sector.

Cement Industry: Climate VISION Partnership - In 2003, as part of the President's Climate VISION initiative, the Portland Cement Association (PCA), on behalf of the U.S. cement industry, committed to a 10 percent reduction in carbon dioxide (CO_2) emissions per ton of cementitious product produced or sold from a 1990 baseline by 2020. The industry will achieve this goal and foster further reductions by end users of their product through the implementation of a three-part program that focuses on the production process, the product of cement manufacturers, and application of the product. The ITP IMF is working with the PCA and Environmental Protection Agency (EPA) to realize this goal through development and implementation of a Climate VISION workplan.

Several IMF activities in FY 2003 facilitated this partnership activity. The update of the *Concrete Industry Roadmap*, which identifies technical challenges and priorities relevant to cement manufacturing, was completed. In addition, *Energy and Emission Reduction Opportunities for the Cement Industry* (BCS), a report which provides background information necessary for the development of realistic work plans to reduce energy use and lower CO_2 emissions, has been prepared.

The Challenge

DOE sponsors materials R&D to lead a national effort to research, design, develop, engineer, and test materials needed for energy efficiency improvements in the IOFs. Through coordinated research and development, validation, and dissemination of innovative materials and materials applications, IMF partners with IOF industries and other stakeholders to achieve the goals of ITP (Exhibit 1). As a priority, DOE fosters high-risk, high-return R&D with the potential to improve significantly energy efficiency, environmental performance, and product yield. The IMF portfolio seeks to identify, support, and nurture promising efforts in materials and processing technologies so they can be demonstrated in industrial applications. Funded activities cover proof of concept, applied research and development, and applications engineering (Exhibit 2). The portfolio is crosscutting, emphasizing longer-range materials needs common to multiple IOFs and encouraging multi-industry partnerships.

Exhibit 1
ITP Goals to Meet the Challenge

- Increase energy efficiency
- Reduce reliance on foreign oil
- Reduce environmental impacts
- Increase use of renewable energy
- Improve competitiveness
- Improve process yield
- Conserve resources
- Improve worker health & safety
- Improve quality of life

Exhibit 2
FY 2003 IMF R&D Addressed

- New corrosion resistant steels, refractories and composites
- Nanocrystalline materials and coatings for industrial applications
- Databases and modeling for alloy design
- Materials for energy-efficient separations
- Tubes, tools and components for industrial processes

Materials Energy Challenges

Advanced materials represent one of the most important and urgent technical needs for the IOFs. The eight IOFs — aluminum, chemicals, forest products, glass, metal casting, mining, petroleum refining, and steel — all cite materials as high-priority R&D in their technology roadmaps, and all IOF technology roadmaps collectively cite at least ten specific materials-related priorities (*Industrial Materials for the Future R&D Priorities*, RAND 2001).

Material properties play a central role in determining the operating parameters and efficiencies of almost all industrial processes. Materials are also the cause of many planned and unplanned process interruptions in which productivity and energy are lost, and safety is compromised. Operating efficiency is also lost as materials corrode, wear, foul, or otherwise degrade. Improved materials that perform better under corrosive, high-temperature, and high-pressure conditions will enable new technologies to save more energy. In addition, a longer lifetime saves the energy and raw materials needed to produce and install replacement materials.

Specific examples of opportunities for improved process technologies can be observed in almost all IOF processes. Separation technologies are among the most energy-intensive operations in the manufacturing of chemical and refining products, accounting for about 41 percent of the total energy used by the chemical process industry (A report on this topic, *Materials for Separations,* is in preparation by ORNL). Paper mills, in addition to being energy-intensive, also consume large amounts of water and produce large volumes of contaminated liquid waste, making them primary candidates for IOF technologies that conserve energy and water, recover valuable processing chemicals, and reduce wastes and emissions. In addition, improved catalyst support materials have the potential to provide significant energy savings. If catalytic processes for the top 50 chemicals were raised to maximum yields, energy savings would exceed 47 TBtu per year; even a process yield improvement of 10 percent would save 23 Btu per year (*Catalysis Workshop Report*, www.eere.energy.gov/industry/chemicals/visions_catalysis.shtml). Improved catalytic and separation materials can help industry to realize much of that opportunity.

Refractories are used in most manufacturing industries. While the steel industry currently consumes 70 percent of the refractories produced globally, the aluminum, cement, chemical, forest products, metal casting and glass industries could all increase energy efficiency by use of improved refractories. Cumulative energy savings in these industries, up to several hundred TBtu per year, could be realized through the implementation of advanced refractories capable of operating at higher temperatures with reduced wall losses and greater resistance to corrosion, erosion, and other forms of degradation (A report on refractories, *Refractory and Insulation Materials R&D Needs and Opportunities for Industries of the Future,* is in preparation by ORNL). The potential benefits are especially great for advanced refractories in equipment applications

relevant to multiple IOFs, such as reverberatory furnaces, ladles, kilns, calciners, and boilers. Improved refractory materials are also needed to fully realize the energy advantage of new technologies such as oxygen-enriched fuel firing.

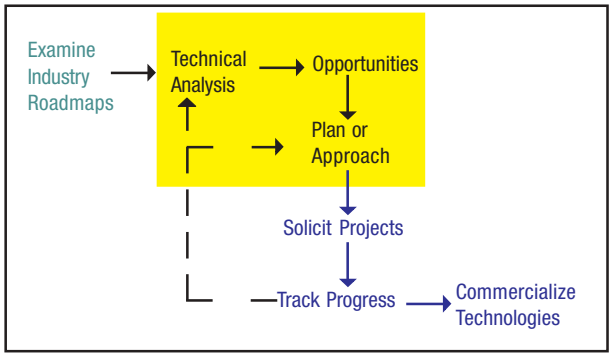
According to ITP's program benefits analysis, Government Performance Results Act 2004, the IMF portfolio is expected to save approximately 28 TBtu per year in 2020 and 39 TBtu per year in 2030. This portfolio represents 7 percent of the overall ITP energy-saving benefits in 2020 and 11 percent in 2030.

The central role of materials R&D in the pursuit of energy savings can be illustrated in nearly every DOE/EERE program. For example, the 13.3 TBtu per year and $95 billion spent to heat and cool buildings in the United States in 2000 could be reduced with improved thermal performance of wall, roof, and floor materials. Every 1 percent reduction in transportation vehicle weight, through stronger, lighter materials, yields a 0.6-0.8 percent improvement in energy efficiency. Advanced tower materials for wind generators could increase tower heights from 100 to 230 feet, allowing access to steadier, stronger winds to increase energy and operating performance. Finally, materials are key to surmounting technical hurdles in hydrogen storage (e.g., materials for ultra-high pressure tanks, distribution systems, flow controllers, and novel storage devices such as metal hydrides and carbon nanotubes), the primary impediment to a hydrogen economy.

Portfolio Strategy/Key Pathways

Historically, the IMF approach to portfolio planning was based on needs identified by individual IOFs. Solicitations were issued for IMF projects that addressed the material needs identified by individual industries in their industry-produced roadmaps. In FY 2003, IMF adopted a new approach to portfolio planning (Exhibit 3), which recognizes that broad R&D needs of industry as a whole will lead to research projects with a higher probability of commercialization and subsequent energy savings. This new approach uses a technical analysis of the IOF roadmaps to identify the energy-savings potential of materials-based R&D. Four priority technical focus areas have been identified, and now form the framework for materials research and development work (Exhibit 4).

Exhibit 3
Program Planning Evolution: New Approach



The need for more technically detailed, material-specific analyses within these four areas has resulted in the start of four analytical studies including:

- Opportunities Within Industries of the Future for Materials R&D Supporting Separation Processes
- Refractory Material Needs for Industries of the Future
- Thermophysical Data and Modeling
- Energy Costs of Corrosion

Exhibit 4
IMF Priority Focus Areas

- Degradation Resistant Materials
  Materials Development and Processing
  Coatings and Surface
  Modifications Refractories
- Thermophysical Databases and Modeling
- Materials for Separations and Catalysis
- Materials for Engineering Components

These reports will examine existing materials' strengths and weaknesses, catalog new material needs, examine approaches for the development of new materials, and estimate the energy-savings and other impacts of new materials R&D work. The reports will specifically attempt to identify the largest energy-savings opportunities across all IOFs and allow the IMF to focus future solicitations on materials that provide significant improvements in energy efficiency. IMF will initiate future analyses based on project performance and industry needs.

A near-term goal for the IMF is to concentrate portfolio resources on a smaller number of projects. The FY 2003 portfolio supported 27 projects. This level of funding often requires extended work periods to obtain meaningful results, and it is anticipated that an earlier application of greater resources to a more select group of projects will expedite bringing the energy savings to market.

FY 2003 Highlights and Accomplishments

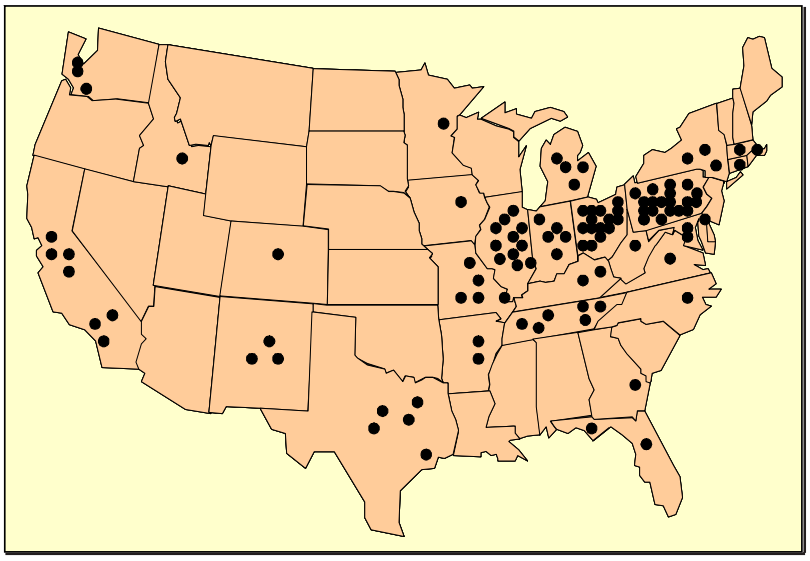
Broad Industry Partnership

One of the strengths of the IMF portfolio is the significant participation of industry partners, who aid research and provide cash and in-kind cost-share. Currently, the portfolio engages 111 partners — 80 industrial, 18 university, ten laboratory, and three industry association — in 28 states. The geographic reach of the IMF is illustrated in Exhibit 5.

Exhibit 5
Geographical Reach of IMF Research

List of IMF Industrial Partners

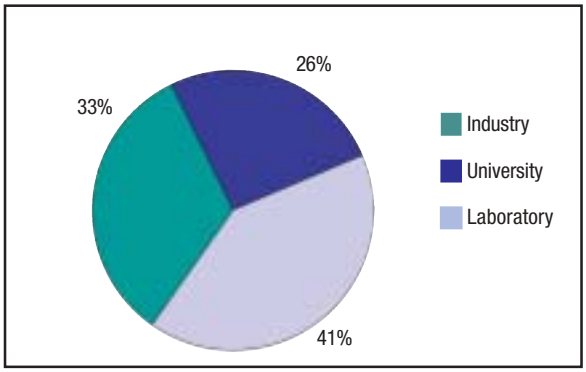
Air Products and Chemicals, Inc.
Allied Mineral
Alloy Engineering
Alon Surface Technologies
ALSTOM Power Incorporated
Altair Engineering
Alvord-Polk Corporation
American Air Liquide
AmeTek
Applied Thermal Coatings
Atofina Chemicals, Inc.
Babcock and Wilcox
Bethlehem Steel Corporation
Boise Cascade Corporation
BP Amoco
Brunner & Lay Inc.
Carpenter Technology Corp.
Caterpillar Technical Center
Center for Welded Structures Research, Battelle
Chicago-Allis Manufacturing Corp.
Coors Technical Ceramics
Crucible Research Int'l
Cummins, Inc.
Dow
DuPont
Duraloy Technologies, Inc.
Dynamet Technology
Ellwood Forge
Emhart Glass
Energy Industries of Ohio
ExxonMobil
Flow Science, Inc.
Flowserve
Ford Motor Company
General Aluminum Manufacturing Co.
Goodyear Chemical
Harper International
Howmet Research Corporation
Hydro Resource Solutions
INCO Alloys International



International Paper
IPSCO
John Deere
Kyanite Mining Corporation
Lund International
Materials Resources, Inc.
Mead Central Research
Monofrax, Inc.
National Forge
Nofsinger (Burns & McDonnell)
Nooter Fabrication
Nooter-Eriksen
NUCOR Steel Corporation
Pilkington North America
Plymouth Tube
PPG Industries, Inc.
Praxair Surface Technologies, Inc.
Progress Castings
Pyrotek, Inc.
QuesTek Innovations
Reaction Design
RHI Refractories
Rock Bit Intl., Gearhart Ind. Inc.
RSP Tooling, LLC
Secat, Inc.
Shell Oil Products Company LLC
Shenango
Solar Turbines
Special Metals Corporation
Spirex Corporation
SRI International
Starfire Systems, Inc.
Stellram
St. Louis Metallizing
Stoody Company
The Timken Company
UES Software
United Defense
Westvaco
Weyerhaeuser

Partnerships spread both cost and risk of R&D, enabling the performance of projects too complex, costly, or time-consuming for individual companies to undertake alone. Industry involvement during the early stages of R&D accelerates technology transfer and dissemination of research results. Partnerships bring together technical expertise, practical experience, and state-of-the-art resources and facilities to dramatically accelerate advances in critical challenge areas. Exhibit 6 illustrates the distribution of IMF funding by organization type.

Exhibit 6
DOE Dollars by Partner, FY 2003



In FY 2003, the IMF had over 80 industry R&D partners, providing the portfolio with approximately 37 percent cost-share funding. Partnerships established around cost-shared projects ensure that the R&D activities undertaken are of real and commercial value to the industry. This approach accelerates the rate of new product diffusion, and garners energy efficiency benefits earlier in the product life cycle. This successful government-industry partnership continues to focus on developing high-impact research projects to make revolutionary improvements in energy efficiency.

Exhibit 7 illustrates IMF funding by general R&D activity for FY 2003. The portfolio addressed the diversity of the IOF industries, with research in degradation resistant materials, databases and modeling, materials for separations and catalysis, and materials for engineering components. Exhibit 8 breaks out the spending percentage of the separate areas of degradation resistant materials, including materials development and processing, coatings and surface modifications, and refractories.

Exhibit 7 Industrial Materials for the Future Spend Plan, FY 2003

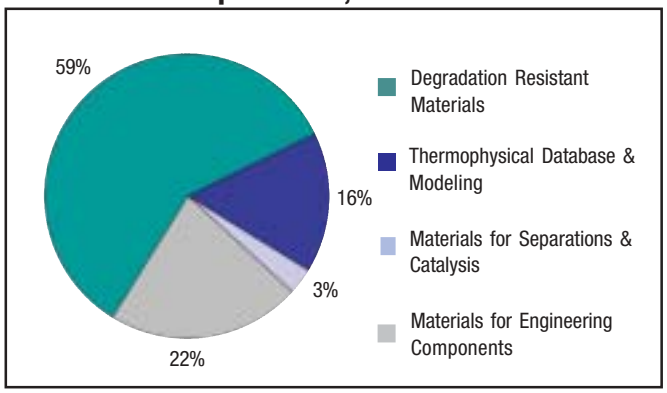
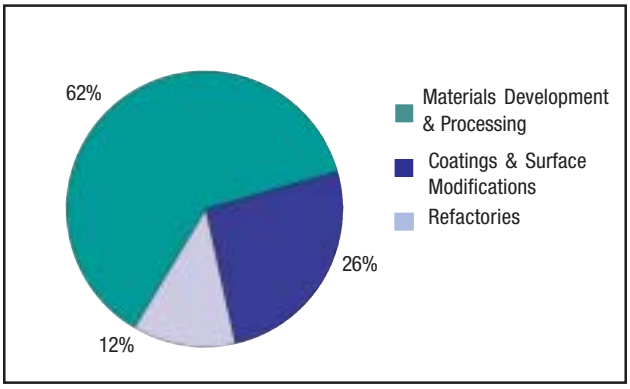


Exhibit 8 Degradation Resistant Materials, FY 2003



A Diverse Research Portfolio

The extended ITP materials portfolio (Exhibit 9) addresses shorter-term materials needs for a specific industry or application, while the IMF portfolio (Exhibit 10) consists of projects boasting broad crosscutting applications in multiple IOFs. The IMF portfolio received $12.7 million in funding in FY 2003 for 27 active projects, most scheduled to end in FY 2004 or FY 2005. The portfolio consisted of multi-partner projects led by industry, universities, or laboratories. In addition to the IMF portfolio, materials R&D is conducted through many of the IOF and ITP crosscutting portfolios.

Exhibit 9
Extended ITP Materials Portfolio

Petroleum
- Global On-Stream Inspection for Mechanical Integrity
- Energy-saving Separation Technology for the Petroleum Industry

Mining
- Fibrous Monolithic Composites as Wear Resistant Components for Mining
- Metal-Matrix Composites and Thermal Spray Coatings for Mining Machines
- Castcon Process for Mining Applications

Chemicals
- Alloys for Ethylene Production
- Metal Dusting Phenomena
- Mixed Solvent Corrosion
- Corrosion Monitoring System
- Alloy Selection System
- Advanced Membrane Materials for Reducing Energy Consumption in P-Xylene Separation
- Affinity Ceramic Membranes with CO_2 Transport Channels

Inventions & Innovation
- Monolithic Refractory Material
- Ceramic Composite Die for Metal Casting
- Fabrication and Testing of a Prototype Ceramic Furnace Coil for Chemical and Petrochemical Processing
- Functionally Graded Materials for Improved High-Temperature Performance of Nd-Fe-B-Based Permanent Magnets
- Low-Cost Synthesis and Consolidation of Titanium Carbide
- Development of a Composite Reinforced Aluminum Conductor
- Manufacturing Wear-Resistant Metal-Reinforced Carbon Composites
- New High-Temperature Coating for Gas Turbine Components
- Products from Metal Powders

Metal Casting
- Grain Refinement of Permanent Mold Cast Copper-Base Alloys
- Mold Materials for Permanent Molding of Aluminum Alloys
- Heat Transfer at Mold/Metal Interface in Permanent Mold Casting of Aluminum Alloys
- Advanced Coatings for Die Castings
- Titanium Matrix Composite Tooling Material for Enhanced Manufacture of Aluminum Die Castings
- Creep Resistant Zinc Alloy Development
- Die Life Extension: Materials for Critical Applications & Increased Production Rates

Sensors and Controls
- Remote Automatic Material On-line Sensor

R&D Highlights

The following examples of current projects display promising results, including some that are now emerging in commercial settings.

Current R&D with Promising Results

Advanced Composite Coatings for Industries of the Future - Pacific Northwest National Laboratory (PNNL) is working with the University of Washington, the University of Central Florida, Alon Surface Technologies, and three additional companies to develop low-cost, high-temperature corrosion-resistant coatings for industrial applications. Thus far, project accomplishments include determining the properties of a family of pre-ceramic polymers, using the polymers to create spin-on coatings, and characterizing those coatings. Researchers have also discovered a low-cost way to produce polysilsesquioxanes by using a by-product of the RTV silicone industry. This by-product can be used to make an inexpensive slurry-based coating that can be readily commercialized. IMF estimates that this project will save approximately 2.7 TBtu and $11.65 million annually by 2020. For more information, please visit http://www.eere.energy.gov/industry/imf/factsheets/pnnl_composite_coatings.pdf.

Development of Advanced Wear and Corrosion Resistant Systems through Laser Surface Alloying and Materials Simulation - The Applied Research Laboratory at Penn State University (PSU) is leading an effort to develop processing and material simulation techniques for identifying and creating reproducible advanced coatings through laser surface alloying (LSA). Project accomplishments include the completion of a heat transfer model for laser surface alloying and an evaluation of the stabilities of TiC and WC when placed in a liquid with a martensitic stainless steel composition. IMF estimates that this project will save approximately 0.4 TBtu annually by 2020. To learn more, please visit http://www.eere.energy.gov/industry/imf/factsheets/arl_laser_coatings.pdf.

Development of Ultrananocrystalline Diamond Coatings - The goal of this project, which is being conducted by Argonne National Laboratory and seven project partners, is to develop ultrananocrystalline

Exhibit 10 IMF Portfolio of Projects and Crosscutting Applications

FY 2003 IMF Projects	Aluminum	Carbon	Chemicals	Combustion	Forest Products	Forging	Glass	Heat Treating	Metal Casting	Mining	Petroleum	Process Heating	Steel	Welding
DEGRADATION RESISTANT MATERIALS														
Alloy Development and Optimization														
Advanced Intermetallic Alloy Development *													●	●
Development of a New Class of Fe-3Cr-W(V) Ferritic Steels for Industrial Process Applications			●		●			●			●	●	●	
Development of Stronger and More-Reliable Cast Austenitic Stainless Steels (H-series) Based on Scientific Design Methodology			●		●			●			●		●	
Fracture Toughness and Strength in a New Class of Bainitic Chromium			●		●			●			●		●	
Crosscutting Industrial Applications of a New Class of Ultrahard Borides					●				●	●				
Materials Processing and Synthesis														
High-Density Infrared Surface Treatments of Refractories *	●		●	●	●		●	●	●	●	●		●	
High-Density Infrared (HDI) Transient Fused Coatings for Improved Wear and Corrosion Resistance	●		●		●		●	●						
High-Energy-Density Coating of High-Temperature Advanced Materials for Energy-Efficient Performance	●		●		●	●	●	●						
Development of Advanced Wear and Corrosion-Resistant Systems Through Laser Surface Alloying and Materials Simulation *	●		●		●	●		●						
Development of Ultrananocrystalline Diamond (UNCD) Coatings for SiC	●		●		●		●	●						
Novel Superhard Materials and Nanostructured Diamond Composites										●	●			
Advanced Composite Coatings for Industries of the Future			●					●			●		●	
Advanced Nanoporous Composite Materials for Industrial Heating	●	●	●				●	●	●		●	●	●	
Ultrasonic Processing of Materials	●								●				●	
Exploring Ultrahigh Magnetic Field Processing of Materials for Developing Customized Microstructures and Enhanced Performance	●		●			●		●	●				●	●
THERMOPHYSICAL DATA and MODELING														
Development of Combinatorial Methods for Alloy Design and Optimization			●		●			●	●	●	●		●	
Inverse Process Analysis for the Acquisition of Accurate Thermophysical		●					●		●				●	●
Stochastic Multi-Objective Optimization of Heat- and Corrosion-Resistant Alloy Properties			●					●				●	●	
Thermochemical Models and Databases for High-Temperature Materials Processing and Corrosion	●		●	●	●		●	●	●	●	●	●	●	
MATERIALS for COMPONENTS														
Stress-Assisted Corrosion (SAC) in Boiler Tubes	●		●		●		●	●	●	●	●			
Development of Cost-Effective Low-Permeability Ceramic and Refractory Components for Aluminum Melting and Casting *	●		●	●		●		●			●			
Virtual Weld-Joint Design Integrating Advanced Materials and Processing					●			●		●	●		●	
Physical and Numerical Analysis of Extrusion Process for Production of High-Performance, Oxide-Dispersion-Strengthened Tubes for Production of Ethylene and Other Industrial Chemicals			●					●			●			
Advanced Chlor-Alkali Technology			●								●			
Development and Demonstration of Advanced Tooling Alloys for Molds and Novel Carbon						●	●	●	●				●	
Films for Next-Generation Rotating Equipment Applications	●		●		●		●		●	●	●		●	
MATERIALS for SEPARATIONS and CATALYSIS														
Novel Modified Zeolites for Energy-Efficient Hydrocarbon Separations			●								●			

*projects scheduled to conclude in FY 2003

diamond (UNCD) films for use as wear-resistant, low-friction coatings for SiC multipurpose mechanical pump seals. Project accomplishments include the successful coating and testing of various automotive, reaction-bonded, and chemical process pump seals; the performance of an economic analysis to determine which seals exhibit the most promising research potential; the establishment of a broader industrial participant base; and the formation of Advanced Diamond Technologies by Argonne National Laboratory to serve as the commercialization vehicle for UNCD technology. IMF estimates this project will save approximately 20.86 TBtu and over $2.4 billion annually by 2020. For more information, please visit http://www.eere.energy.gov/industry/imf/factsheets/anl_diamond_coatings.pdf.

Advanced Nanoporous Composite Materials for Industrial Heat Applications - The benefits of this research, conducted by Lawrence Berkeley National Laboratory (LBNL) and Anter Corporation, include the development of improved insulation materials that will reduce heat losses from furnaces and other process heating applications, thereby lowering the energy required for industrial production processes. Accomplishments include the development of a variety of chemical pathways to produce gels, including the formulation of alcogels that exhibit microstructured properties even after prolonged exposure to high temperatures. Researchers also discovered an unconventional route for creating chromia/alumina gels that can reduce raw material costs from $118 per pound to $2 per pound. MF estimates that this project will save approximately 0.43 TBtu and $2.2 million annually by 2020. To learn more, please visit http://www.eere.energy.gov/industry/imf/factsheets/lbnl_composites.pdf.

High Density Infrared Surface Treatment of Refractories - The overall goal of this project, conducted by Oak Ridge National Laboratory (ORNL), the University of Missouri-Rolla, and three industrial project partners, is to improve the behavior of refractory materials used in industrial processing through surface modifications with high density infrared (HDI) processing. Among other findings, research has shown that HDI treatment of commercial refractories leads to surface melting at moderate power levels for aluminosilicate-based materials, while higher power levels were required for alumina compositions. Additionally, researchers have demonstrated that wetting or corrosion can be inhibited by bonding an adherent coating onto the underlying refractory. IMF estimates that this project will save approximately 0.51 TBtu and $2.2 million annually by 2020. For more information, please visit http://www.eere.energy.gov/industry/imf/factsheets/ornl_hdi.pdf.

Novel Modified Zeolites for Energy-Efficient Hydrocarbon Separations - This project, which is led by Goodyear Chemical and conducted with project partners Sandia National Laboratories and Nofsinger Process & Industrial Group, focuses on developing novel, modified zeolites for energy-efficient hydrocarbon separations. Thus far, project accomplishments include the construction of pilot plants at a Goodyear site and at Sandia National Laboratories. Researchers have also begun separation experiment testing at the Goodyear pilot plant unit. IMF estimates that this project will save approximately 38.14 TBtu and over $417 million annually by 2020. For more information, please visit http://www.eere.energy.gov/industry/imf/factsheets/goodyr_zeolites.pdf.

Thermochemical Models and Databases for High-Temperature Materials Processing and Corrosion - Sandia National Laboratories and ORNL are working with nine industrial partners on a project to improve the availability, accuracy, and accessibility of thermochemical property data that is required to understand, simulate, and optimize industrial processes that involve glass and refractory materials. Project accomplishments and milestones center on developing thermodynamic models of condensed-phase systems, prediction of high-temperature thermochemistry of gas-phase species, and the development of a Web-based database/model site that will provide the necessary input for commercial operation. IMF estimates that this project will save approximately 0.9 TBtu and $3.8 million annually by 2020. To learn more, please visit http://www.eere.energy.gov/industry/imf/factsheets/snl_ornl_thermo.pdf.

Applying R&D Results

Industry is adopting IMF research into their operations. The following provide examples of technologies that are moving beyond the bench and into the plant.

New Intermetallic Alloys Lead to More Efficient Carburization of Steels - Delphi has collaborated with ORNL to utilize a new nickel aluminide alloy (Ni_3Al) developed by ORNL in fixtures in carburizing furnaces. Carburizing furnaces are large gas-fired systems (about 150 feet long) that heat treat hundreds of tons of steel each day. The carburization process itself is used to modify the near surface of steel parts to increase strength and durability in final applications. Thus far, Ni_3Al fixtures have demonstrated increased corrosion resistance, survived three to five times longer than current high-performance steel alloys, and are at least three times stronger at operating temperature than conventional alloys. These properties have led to increased energy and production efficiencies, reduced fuel and capital equipment costs, and enabled Delphi to meet production goals while building only two new furnaces (three would have been required with current technology fixtures). Delphi is now in the process of changing all of the fixtures used in their carburizing furnaces to Ni_3Al fixtures; over 500 have been installed and are operating in two continuous pusher steel carburizing furnaces. Replication of this success can impact 30 percent of the overall heat treating industry and result in improved efficiencies of about 20 percent leading to energy savings of nearly 30 TBtu per year in 2020. For more information, please visit http://www.eere.energy.gov/industry/imf/pdfs/ni3alheatfurnace.pdf and http://www.eere.energy.gov/industry/imf/pdfs/intermetallicalloystudy8_9.pdf.

Process Improvements from New Roller Material Being Evaluated: 101 Nickel Aluminide Rollers Installed in Steel Reheat Furnace - Steel reheat furnaces are used to heat treat steel slabs and plates prior to further processing. Currently, the rollers that transfer steel slabs through a furnace have severe problems with blistering and bending, which result in increased slab rejection rates and energy use. The new nickel aluminide intermetallic alloy has properties superior to current alloys, including increased oxidation resistance, high-temperature strength, and resistance to blistering. The use of these new transfer rollers can lead to fewer rejected slabs, improved productivity, elimination of biweekly furnace shutdowns (required to resurface current alloy rollers), and improved energy efficiency.

A team from ORNL and ISG (formerly Bethlehem Steel) is testing rollers made from nickel aluminide in a commercial steel reheat furnace. The full complement of 101 nickel aluminide rollers, fabricated by Duraloy Technologies and Ultracast, has been installed and under test for over 9 months at the ISG Burns Harbor facility. Further research has focused on developing commercial practices for melting and casting rollers (including recycling of cast materials and welding of nickel aluminide rollers to steel trunnions), evaluating the rollers in a reheat furnace, and assessing process improvements resulting from the use of the new roller material. When fully developed, this application will save 10.8 TBtu per year and greatly increase the reliability of rolling operations. For more information, please visit http://www.eere.energy.gov/industry/imf/pdfs/intmetalloydevsteel.pdf and http://www.eere.energy.gov/industry/imf/pdfs/intermetallicalloystudy8_9.pdf.

Materials Efforts Key to Solving Critical Issue in Forest Products: Cracking of Floor Composite Tubes in Kraft Recovery Boilers - Kraft recovery boilers, central to pulp and paper mills, recover chemicals used in the pulping process and produce nearly all of the process steam used for drying and co-generation of electricity. Cracking of kraft recovery composite tubes is a critical energy and safety issue in the boilers. The team on this project consisted of 18 pulp and paper companies, lead by Weyerhaeuser, three boiler manufacturers, two materials suppliers, and three research organizations including ORNL, the Institute of Paper Science and Technology, and the Pulp and Paper Research Institute of Canada. Researchers performed unique residual stress measurements to show the impact of service conditions on the cracking behavior of tubes. Computational models were developed and used to evaluate the impact of manufacturing processes on the properties of tubes; determine the impact of boiler operations, including shutdown procedures, on stresses in tubes; and optimize the properties of tube materials. In addition, researchers performed experimental corrosion measurements of laboratory and test panels that proved critical in identifying feasible R&D solutions. The new boiler floor tube technologies have been installed in nine pulp and paper mills (as either complete boiler floors or partial floor replacements) operated by Weyerhaeuser, Mead Westvaco, Irving P&P, P. H. Glatfelter, and Domtar. Two additional installations are planned in Weyerhaeuser and Georgia Pacific facilities. Analysis suggests that a strategy that combines improved maintenance procedures to avoid cracking

with somewhat accelerated tube replacement will provide cumulative industry savings of 66 TBtu by 2030. In addition, these energy savings translate into reductions of nitrogen oxides, sulfur dioxide, and carbon-based greenhouse-gas emissions. For more information, please visit http://www.eere.energy.gov/industry/imf/pdfs/recoveryboilers.pdf and http://www.eere.energy.gov/industry/imf/pdfs/pulppaperboilermaterials.pdf.

IMF Supports First Industrial-Scale Production Test of New High-Strength Tungsten Alloys for Use in Chemical Processes and Heat Recovery Steam Generator Systems - Chemical reaction vessels can be up to 30 feet in diameter, weigh 300 tons, and have hundreds of reaction tubes within the main vessel. ORNL and Nooter Corporation are developing new alloys for reaction vessels that offer two main advantages including higher strength and the possible elimination of post-weld heat treatment of fabricated structures. By offering 50 percent greater strength, the new alloys allow for thinner wall sections of the main vessel and thinner heat transfer tubes, improving effective thermal conductivity. Additionally, by eliminating the need for post-weld heat treatment of the fabricated vessels, large heat treating furnaces can be eliminated.

The first industrial-scale production test of the new alloys, using two commercial-sized heats of approximately 40 tons each, is underway at Ellwood Quality Steel in Ellwood City, PA. The ingots from these heats will be rolled into plate, forged into elbows, and extruded into tubing by other industrial project partners. The industrial-scale tests will allow researchers to evaluate any issues surrounding the scale-up of laboratory compositions with respect to melting and casting practices, determine the conditions for thermomechanical processing of ingots into various shapes, and develop the ASTM specifications and ASME boiler and pressure vessel code design for allowable stresses for the new alloys. It is estimated that this IMF project will save 21 TBtu per year in 2020. For more information, please visit http://www.eere.energy.gov/industry/imf/factsheets/nooter_steels.pdf.

Successful Real-Time Evaluation of Mold Filling in Lost Foam Casting Process Achieved by Infrared and Optical Imaging, X–ray Transmission, and Capacitive Imaging Systems - For the first time, the evaluation of metal flow and foam decomposition were simultaneously imaged successfully in a lost foam metal casting. It is anticipated that the understanding gained will lead to fewer defects in castings produced by the lost foam casting process. The goal of this Metals Processing Laboratory Users (MPLUS) effort is to correlate and quantify relationships between liquid pyrolysis and gas generation caused by metal advancement through the foam pattern.

This project involved collaboration between General Motors Corporation (x-ray real-time imaging and aluminum casting), ORNL (IR and optical imaging), Foseco (experimental casting system, and lost foam test patterns), Metals Casting Technology Inc. (computational casting model), University of Alabama-Birmingham (data evaluation), D8 Corporation (innovative approach to pattern manufacturing), and Walford Technologies (capacitive imaging system and coordination). The tests were made at the GM Casting Development and Validation Center in Saginaw, MI. For more information, please visit http://www.ms.ornl.gov/programs/mplus/mplus.htm.

Researchers Identify Improved Process for Minimizing Dross Formation in Aluminum Recycle Secondary Ingots (RSI) - A study at the MPLUS facility at ORNL, in conjunction with Logan Aluminum, has led to a new and significantly improved understanding of the role of Recycled Secondary Ingot (RSI) melting and casting practices in dross formation. The study focused on the 5182 high-magnesium aluminum alloy used to produce can lid stock. At the Logan plant, approximately 75 million pounds of RSI ingot are used in 5182 alloy production each year, of which over one-third has been shown to have high dross content. The high-dross content has been linked to processing conditions during the solidification of the RSI ingots. Findings indicate that rapid cooling leads to low dross content while slow cooling leads to high dross content. Improving 5182 aluminum alloy RSI solidification practices at recycle facilities or, alternatively, eliminating the use of high-dross 5182 RSI at Logan can lead to an estimated energy benefit in the order of 0.34 TBtu per year. On a national level, the possible impact of these findings for 5182 aluminum alloy production could lead to energy savings of nearly one TBtu per year. Additional benefits are expected when this new understanding is applied to the production of other high-magnesium aluminum alloys. For more information, please visit http://www.ms.ornl.gov/programs/mplus/mplus.htm.

Partnership Highlights

In addition to partnering in R&D projects, the IMF works with other organizations to accomplish the goals of the ITP.

The Metals Processing Laboratory Users Facility (MPLUS) - MPLUS is an Industrial Technologies Program user facility designated to assist in research to improve energy efficiency, environmental performance, and competitiveness in industry. MPLUS receives a portion of its funding directly from the IMF to support research and development efforts of concern to the IOF. The goal of MPLUS is to provide access to specialized technical expertise and equipment needed to solve metals processing issues currently limiting the development and implementation of emerging metals processing technologies. The scope of work can also extend to other types of materials, and MPLUS offers industry and academia access to unique DOE laboratory capabilities to address key industrial materials issues.

Annual reporting of MPLUS activities has recently been initiated, beginning with the complete FY 2001 report. MPLUS conducted 30 projects in 2001, a number of which were found to have high potential energy benefits. Four of them in particular could result in a cumulative energy savings of 60 billion Btu per year. MPLUS objectives for fiscal years 2003 and 2004 are to continue to publish and distribute annual reports on MPLUS research activities, increase participation of IOF partners, and to quantify energy benefits on existing projects and future work in order to focus its efforts on those projects that provide the highest impact on energy savings.

Intra-EERE/Government Activities - In addition to close work with industrial and academic partners, IMF seeks opportunities to coordinate with other government groups to maximize resources and research. Some of these include:

- **SBIR Topic -** The IMF researched and developed a Small Business Innovation Research (SBIR) topic, *Materials for Industrial Energy Systems*, which has been selected for the 2004 SBIR solicitation.
- **EMaCC report -** The IMF contributed to and helped fund the annual Energy Materials Coordinating Committee (EMaCC) report. EMaCC serves primarily to enhance coordination among DOE materials programs and to further effective use of materials expertise within DOE. These functions are accomplished through the exchange of budgetary and planning information among technical managers and through technical meetings/workshops on selected topics involving both DOE and major contractors. In addition, EMaCC assists in obtaining materials-related inputs for both intra-agency and interagency compilations. For more information, please visit http://www.eere.energy.gov/industry/imf/pdfs/emaccreport_fy2001.pdf.
- **Annual Interagency Metals Meeting -** The IMF organizes, coordinates and participates in an annual Interagency Metals Meeting and distributes the proceedings to participants.

Roadmaps and Workshops

***Technology Roadmap for Materials of Construction for the Chemical and Allied Process Industries* -** This roadmap, originally developed in partnership with the Materials Technology Institute in 1998, was revised this year to reflect the new technological and economic circumstances of 2003. IMF worked with the Materials Technology Institute (MTI) to update the targets, technical barriers, and R&D priorities within the roadmap to help guide future R&D in the area of materials of construction. The roadmap identifies three major challenges for materials of construction including delivery of materials engineering information, modeling and prediction of materials performance, and condition assessment. *Soon to be available on-line.*

***U.S. Concrete Industry Technology Roadmap 2030* -** The concrete roadmap, which addresses the eight goals identified in *Vision 2030: A Vision for the U.S. Concrete Industry*, was prepared by the American Concrete Institute Strategic Development Council in 2003. *Roadmap 2030* highlights existing state-of-the-art technologies and emerging scientific advances, predicts future technological needs, defines enabling research opportunities, and proposes areas where governmental-industrial-academic partnerships can accelerate the pace of development. The eight goals featured in the roadmap center on process improvements, product performance, energy efficiency, environmental performance, technology transfer, institutional improvements, education and employment, and industry image. The roadmap is available on the EERE Industrial Technologies Web site at http://www.eere.energy.gov/industry/imf/pdfs/concrete_rdmap.pdf.

Materials for Process Heating - The DOE/IHEA Materials Forum, held February 5-6, 2003 at ORNL, was attended by 56 representatives from industry, equipment suppliers, and research scientists and engineers from DOE and several national laboratories. The purpose of the forum was to provide an environment in which representatives from the process heating industry, the associated user community, and scientists and researchers from the national laboratories and elsewhere could share information on recent R&D and discuss the future research needs of the process heating industry. Representatives from DOE-EERE and IHEA, as well as members of industry and scientists from the national laboratories, made presentations on various areas of materials technology and their applications to process heating systems. Roundtable sessions focused on high-temperature alloys, refractories and insulation, and advanced ceramics. The proceedings of the meeting are available on the IMF Web site at http://www.eere.energy.gov/industry/imf/pdfs/advanced_materials_forum_report.pdf. The proceedings served as input in the development of an EERE SBIR topic for FY 2004, *Materials for Industrial Energy Systems*. The summary report from this meeting identifies areas of research and development that demonstrate particular promise for the process heating industry and comments on a strategy for DOE and the national laboratories to work with the industry to proceed with research and development that meets future industry needs.

New Materials and Technologies Available for Use in Industrial Infrastructure - This publication was prepared by the Civil Engineering Research Foundation (March 2003) to provide an overview of the various construction materials options available for industrial infrastructure. These infrastructure materials and the technologies used to apply them are a determinant of industrial capacity and efficiency and have a significant environmental and economic impact on U.S. manufacturing. The paper is intended to promote a dialogue concerning infrastructure materials research and developments, future R&D efforts, and obstacles to innovation. For more information, please visit http://www.eere.energy.gov/industry/imf/pdfs/cerffinalreport03.pdf.

Climate VISION

On February 14, 2002, President Bush announced a new strategy to address the long-term challenge of global climate change. The President committed to reducing America's greenhouse gas intensity — the ratio of emissions to economic output —by 18 percent in the next decade, and challenged American businesses and industries to undertake broader efforts to help meet the goal. The President's strategy, known as Climate VISION (Voluntary Innovative Sector Initiative: Opportunities Now), is focused on voluntary partnerships between the government and entire industry sectors. These partnerships aim to reduce the projected growth in America's greenhouse gas emissions through research, development, and deployment of energy-saving technologies and processes.

The U.S. Department of Energy, along with other key Federal Agencies, recognizes that major, energy-intensive sectors of the American economy are undertaking significant initiatives to meet the President's challenge. These initiatives build upon the progress made by the industrial sector in the past decade: from 1990-2001. During this time, the economy grew by almost 40 percent, while greenhouse gas emissions in the industrial sector remained constant. The Industrial Technologies Program (ITP) is working in partnership with the U.S. cement industry through the Portland Cement Association (PCA) to implement activities in support of the PCA achieving its Climate VISION commitment. PCA's Climate VISION goal is to reduce CO_2 emissions/per ton of product by 10 percent from 1990 levels. ITP is working with the PCA and the U.S. Environmental Protection Agency to develop a Climate VISION workplan to meet the goal. (see Climate VISION Web site www.climatevision.gov/).

A report was prepared by BCS, Incorporated, ***Energy and Emission Reduction Opportunities for the Cement Industry,*** (BCS, 2003), which describes the cement industry as a whole and its technology. It provides background information necessary for DOE EERE and ITP to work with the PCA and EPA to develop a realistic workplan to reduce energy usage and to lower CO_2 emissions. This report finds that opportunities exist both in the near-term and in the long-term for reducing energy usage and lowering emissions. These improvements can come from utilizing free and low-cost options that include: motor, compressed air, and process heating optimization software tools; participating in local and regional energy management training, workshops, and seminars; and conducting university-based energy assessments. Other site-specific near-term energy and environmental improvements can be achieved with formal energy audits. Changes in product formulation also offer significant near-term energy and environmental improvement. Longer-term

improvements could come from advanced research and development programs. Successful R&D portfolios will require significant collaboration between industry, government, and academia. The IMF can assist the industry in developing the advanced materials that allow process optimizations or new process development. Cement manufacturing process and product formulation R&D results will be crosscutting and apply to multiple IOF and other industries that comprise EERE's stakeholders.

Solicitations

The EERE-ITP FY 2003 solicitation for IMF was open between December 9, 2002, and February 27, 2003. Of 59 proposals submitted, 12 were selected for negotiation. The materials research and development projects are worth approximately $34 million, and address national goals for energy and the environment, as well as priority needs identified by the Industries of the Future. The DOE will provide over $20 million to these 12 new R&D projects, and industry partners will provide the remaining $14 million, for an industry cost-share of approximately 41 percent of the total.

Improving Energy Efficiency Today

BestPractices - BestPractices, part of DOE's ITP, works with industry to identify plant-wide opportunities for energy savings and process efficiency. Through the implementation of new technologies and systems improvements, companies across the United States are achieving immediate savings results. Involvement in BestPractices allows companies to join the ranks of forward-thinking U.S. industrial manufacturers who are saving energy and money, reducing pollution and emissions, and increasing productivity today.

Disseminating Research Results to Industry - The IMF performs various outreach activities to disseminate R&D results and enable industry to implement energy-saving practices and technologies. This includes participating in trade shows and maintaining an up-to-date Web site that highlights IMF activities. In addition, IMF conducts an annual portfolio review with industry and provides bi-annual highlights of research activities.

Annual Review: The annual review of the Industrial Technologies Program's Industrial Materials for the Future (IMF) portfolio was held June 23-25, 2003, in Golden, CO, with participants from universities, industry, and the national laboratories in attendance, as well as representatives from the Denver Regional Office, the Golden Field Office, and the National Renewable Energy Laboratory (NREL). During the event, the principal investigators for 25 IMF-sponsored projects reported on their progress for the past year and outlined the direction of future activities. DOE staff met to review IMF project plans and the annual portfolio for the IMF research area evaluation board.

Energy Analysis - Targeting Energy Efficiency

The IMF is targeting annual energy savings of over 245 TBtu per year in 2020. Exhibit 11 shows the projected saving by IMF focus area.

Exhibit 11 IMF Energy Savings

IMF Area	TBtu per year Savings	
	2010	2020
Degradation - Resistant Materials	12.3	150.4
Thermophysical Databases & Modeling	0.4	7.1
Materials for Separations	1.3	38.1
Materials for Engineering Components	3.3	50.1
Total	17.3	245.7

Tools, Publications, and Resources Available

Many of the publications available from IMF are listed below. To view these documents and applications please visit: www.eere.energy.gov/industry/imf/tools.shtml.

Industrial Materials for the Future Review Meeting - Presentations and project summaries from the Annual Review Meeting of Industrial Materials for the Future, June 23-25, 2003.

Highlights of the IMF Portfolio - Bi-annual update of selected IMF research, milestones and events.

EMaCC Report - The *Annual Technical Report for the Energy Materials Coordinating Committee* (EMaCC).

New Materials and Technologies Available for Use in Industrial Infrastructure - A review of construction materials options and the impact on industrial infrastructure produced by the Civil Engineering Research Foundation, March 2003.

Advanced Materials for Process Heating - Proceedings of Workshop on Advanced Materials for Process Heating, February, 2003.

Concrete Industry Technology Vision - On September 27, 2000, the concrete industry's Strategic Development Council hosted a Concrete Vision Workshop in Chicago, Illinois. Meeting participants included over 50 concrete, cement, and other allied industry chief executive officers, presidents, vice-presidents, laboratory and industry research managers, and government representatives. Participants discussed the state of the concrete industry 30 years ago, the state of the industry today, and their vision for the United States concrete industry in 2030. Moreover, they identified specific goals to achieve the industry's *Vision 2030*. This document, *Vision 2030*, is the product of that workshop and the comments received after a broad industry review.

Roadmap 2030: The U.S. Concrete Industry Technology Roadmap - This document tracks the eight goals published in the American Concrete Institute Strategic Development Council's Vision 2030: A Vision for the U.S. Concrete Industry. *Roadmap 2030* highlights existing state-of-the-art technologies and emerging scientific advances that promise high potential for innovation and predicts future technological needs. It defines enabling research opportunities, and proposes areas where governmental-industrial-academic partnerships can accelerate the pace of development. *Roadmap 2030* is a living document designed to continually address technical, institutional, and market changes.

Fact Sheets - The IMF disseminates information on current and past projects through project fact sheets. The information provided in each fact sheet includes the objectives, accomplishments, benefits, principal investigator, and project partners. All IMF fact sheets are available on-line at: http://www.eere.energy.gov/industry/imf/portfolio.shtml.

How To Get Involved And Contact Information

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at www.eere.energy.gov/industry.

- Collaborative, **cost-shared research and development** projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.

- **Industries of the Future Partnerships** increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.

- **Allied Partnerships** provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.

- **State energy organizations** work with ITP in applying technology to assist their local industries. ITP assists states in developing IOF partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.

- **EERE's technical programs** (of which ITP is one of eleven) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at www.eere.energy.gov.

- The President's **Climate VISION** (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at www.eere.energy.gov/industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers **energy management best practices** to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.

- Our suite of powerful system optimization **software tools** can help plants identify and analyze energy-saving opportunities in a variety of systems.

- **Training sessions** are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified **industrial energy specialists** will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of **publications** gives companies the resources they need to achieve immediate energy savings.

- **Plant-wide energy assessments** are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.

- The **DOE Regional Offices** provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in Atlanta, Boston, Chicago, Denver, Philadelphia, and Seattle. Visit www.eere.energy.gov/rso.html for more information.

Where to Get More Information

Learn about all EERE programs - www.eere.energy.gov

Ask an Expert - The Office of Industrial Technologies Clearinghouse is a great way to access ITP's resources. Times available are 9 a.m. to 8 p.m. EST (6 a.m. to 5 p.m. PST).
Phone: 1-800-862-2086
Fax: 360-956-2214
E-mail: clearinghouse@ee.doe.gov

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Industrial Materials for the Future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry

U.S. Department of Energy
Energy Efficiency and Renewable Energy

published January 2004